UNIVERSITI PUTRA MALAYSIA

FIELD DECOMPOSITION OF OIL PALM FROND AND ITS EFFECT ON SOIL PHYSICAL PROPERTIES

MOHD ALI BIN AMAN

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FIELD DECOMPOSITION OF OIL PALM FROND AND ITS EFFECT ON SOIL PHYSICAL PROPERTIES

by

MOHD ALI BIN AMAN

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" Dedicated To My Mother and Father "

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MOHD ALI BIN AMAN

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Chairman : Professor Dr. Haji Wan Sulaiman bin Wan Harun

Faculty : Agriculture

The growth of agro-based industry in recent years has created a strong competition against the traditional use of oil palm fronds purely to mulch frond avenues in oil palm plantations. Meanwhile, increased mechanization continues to cause soil compaction in harvesting paths which act as sub-agricultural roads. Approximately, 50% of an oil palm area is made up of harvesting paths, thus the resulting soil compaction could have a serious impact on palm growth and yield in the long term. Therefore, the objective of this research was to study the decomposition of oil palm fronds placed on the harvesting path and its effect on soil physical properties.

Harvesting paths at Universiti Putra Malaysia oil palm plantation was mulched with oil palm fronds at four different rates of biomass, F1 (9.2 kg $plot^{-1}$), F2 (18.4 kg $plot^{-1}$), F3 (27.6 kg $plot^{-1}$) and F4 (36.8 kg $plot^{-1}$) representing respectively 25%, 50%, 75% and 100% of the total frond harvested in a year. Unmulched plots were used as control. There were 3 replicates in each treatment and the plots were arranged in randomized complete block design (RCBD). Each plot measures 5.5 m wide and 7.0 m long. The rate of decomposition was determined by destructive tissue sampling of the standing biomass at 0, 3, 6 and 9 months after mulching. At the same time the changes in physical properties within the 0-15 cm soil depth were also monitored. The soil properties analysed were soil organic matter, aggregate stability, bulk density, penetration resistance, available water holding capacity, soil infiltrability and saturated hydraulic conductivity.

After nine months of observation, it was found that treatment F1 produced the highest percent of oil palm frond decomposed (73%) while the highest rate of decomposition (8.4 kg $month^{-1}$) produced by treatment F4. The percent of oil palm frond decomposed increased with time whereas the rate of decomposition decreased. As a result of decomposition, the organic matter of the 0-15 cm soil depth increased by 0.32%, 0.38%, 0.39%, and 0.83% for treatments F1, F2, F3 and F4 respectively. There was no increase in organic matter for the unmulched plot.

In the same period, frond mulching gave a significant effect on the soil physical properties. The aggregate stability index was increased to 2.08, 2.77, 2.73 and 3.40 by treatments F1, F2, F3 and F4 respectively. Soil bulk density decreased to 1.21, 1.12, 1.11 and 1.08 g cm^{-3},a reduction of 0.08, 0.15, 0,16 and 0.19 g cm^{-3} respectively. For the unmulched plot, the bulk density showed a non-significant increase of 0.02 g cm^{-3} to 1.30 g cm^{-3}. The total reduction of penetration resistance produced by treatments F1, F2, F3 and F4 were 39, 82, 108 and 93 N cm^{-2} respectively. It was found that the available water holding capacity had increased to 0.13, 0.17, 0.20 and 0.23 cm^3 cm^{-3}, i.e., an increase of 0.08, 0.11, 0.14 and 0.17 cm^3 cm^{-3} respectively. However, no increase was observed for the unmulched plot. Meanwhile, the different rates of frond mulching did not give a significant difference among each other in terms of soil infiltrability (K_f). Treatments F1, F2, F3 and F4 had increased K_f to 14.70, 16.50, 21.00 and 27.00 cm h^{-1} compared to their original values of 6.0, 7.2, 5.4 and 1.2 cm h^{-1} respectively. There was no significant difference in terms of the effect on saturated hydraulic conductivity (K_s) between the mulched and unmulched plots. Overall, it can be concluded that, the higher the mulching rate, the greater the changes in the soil organic matter content and the associated physical properties.

Each of the oil palm frond rate has the possibility of being chosen as the appropriate mulching rate based on several factors such as topography, soil texture, location of the plantation and availability of agro-based industry. In this connection, four scenarios showing the benefit of mulching with different rates of oil palm

fronds are elaborated. The information obtained from this study can be used for reengineering the conventional agronomic practise in order to sustain the crop productivity.

Abstrak tesis yang dikemukakan kepada Senat Univesiti Putra Malaysia sebagai memenuhi syarat keperluan untuk mendapatkan Ijazah Master Sains Pertanian.

PEREPUTAN PELEPAH KELAPA SAWIT DI LADANG DAN KESANNYA KEPADA SIFAT FIZIK TANAH

Oleh

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Fakulti : Pertanian

Perkembangan industri berasaskan pertanian pada masakini menimbulkan persaingan terhadap penggunaan pelepah kelapa sawit secara tradisional semata-mata sebagai sungkupan di lorong pelepah di ladang-ladang kelapa sawit. Peningkatan mekanisasi terus menyebabkan kepadatan tanah di lorong tuai yang digunakan sebagai sub-jalan pertanian. Lorong tuai merangkumi kira-kira 50% daripada keluasan sesuatu kawasan ladang. Oleh itu, kepadatan tanah yang terhasil boleh memberikan impak yang serius kepada pertumbuhan dan hasil pokok sawit dalam jangkamasa panjang. Oleh kerana itu, objektif penyelidikan ini adalah untuk mengkaji pereputan pelepah kelapa sawit yang ditempatkan di lorong tuai dan

kesannya kepada sifat fizik tanah.

Lorong tuai ladang sawit Universiti Putra Malaysia diberikan sungkupan pelepah sawit pada 4 kadar biojisim iaitu F1 (9.2 kg $plot^{-1}$), F2 (18.4 kg $plot^{-1}$), F3 (27.6 kg $plot^{-1}$) dan F4 (36.8 kg $plot^{-1}$) bersamaan masing-masing 25%, 50%, 75% dan 100% daripada jumlah pelepah dituai dalam setahun. Plot kosong tanpa sungkupan digunakan sebagai kawalan. Tiap-tiap satu rawatan mempunyai 3 replikasi. Plot-plot disusun mengikut rekabentuk rawak penuh berblok (RCBD). Setiap plot mempunyai ukuran 5.5 m lebar dan 7.0 m panjang. Kadar pereputan ditentukan dengan persampelan destruktif tisu yang masih kekal pada 0, 3, 6 dan 9 bulan selepas sungkupan. Penentuan perubahan sifat fizik tanah pada kedalaman 0-15 cm dijalankan pada masa yang sama. Sifat fizik tanah yang dikaji merangkumi bahan organik, ketumpatan pukal, kerintangan penembusan, kestabilan aggregat, keupayaan pegangan air tersedia, kepenyusupan tanah dan konduktiviti hidraulik tepu.

Selepas pemerhatian selama 9 bulan didapati rawatan F1 menghasilkan peratus pereputan pelepah tertinggi (73%) manakala kadar pereputan pelepah tertinggi (8.4 kg $bulan^{-1}$) pula dihasilkan oleh rawatan F4. Apabila masa bertambah, peratus pereputan pelepah meningkat manakala kadar pereputan pula menurun. Hasil daripada pereputan, kandungan bahan organik pada kedalaman 0-15 cm oleh rawatan F1, F2, F3 dan F4 masing-masing meningkat 0.32%, 0.38%, 0.39% dan 0.83% . Tidak ada peningkatan bahan organik bagi plot tanpa sungkupan.

Dalam masa yang sama didapati sungkupan pelepah memberikan kesan yang bermakna kepada sifat-sifat fizik tanah. Indeks kestabilan aggregat meningkat masing-masing kepada 2.08, 2.77, 2.73 dan 3.40 bagi rawatan F1, F2, F3 dan F4. Ketumpatan pukal berkurangan masing-masing kepada 1.21, 1.12, 1.11 dan 1.08 g cm^{-3} iaitu pengurangan 0.08, 0.15, 0.16 dan 0.19 g cm^{-3}. Bagi plot tanpa rawatan, ketumpatan pukal meningkat 0.02 g cm^{-3} walaupun tidak bererti kepada 1.30 g cm^{-3}. Jumlah pengurangan kerintangan penembusan yang dihasilkan oleh rawatan F1, F2, F3 dan F4 masing-masing ialah sebanyak 39, 82, 108 dan 93 N cm^{-2}. Didapati keupayaan pegangan air tersedia bertambah kepada 0.13, 0.17, 0.20 dan 0.23 cm^3 cm^{-3} iaitu penambahan 0.08, 0.11, 0.14 dan 0.17 cm^3 cm^{-3}. Akan tetapi tiada penambahan bagi plot tanpa sungkupan. Sementara itu, kadar sungkupan pelepah yang berbeza tidak memberikan perbezaan bermakna di antara satu dengan lain terhadap kepenyusupan tanah (K_f). Rawatan-rawatan F1, F2, F3 dan F4 telah meningkatkan K_f kepada 14.70, 16.50, 21.00 dan 27.00 cm j^{-1} berbanding dengan nilai-nilai asal mereka iaitu 6.0, 7.4, 5.4 dan 1.2 cm j^{-1}. Didapati plot yang bersungkupan dan tanpa sungkupan tidak mempunyai kesan yang berbeza erti terhadap konduktiviti hidraulik tepu (K_s). Pada keseluruhannya bolehlah disimpulkan bahawa semakin tinggi kadar sungkupan semakin besar perubahan kandungan bahan organik dan sifat-sifat fizik tanah yang berkaitan dengannya.

Setiap kadar pelepah sawit mempunyai kebarangkalian dipilih sebagai kadar sungkupan yang sesuai berdasarkan kepada beberapa faktor seperti topografi, tekstur tanah, lokasi ladang dan kedudukan industri berasaskan pertanian. Empat senario

menunjukkan faedah sungkupan dengan kadar penempatan pelepah yang berbeza diperjelaskan. Maklumat yang diperolehi daripada kajian ini boleh digunakan untuk menjana semula amalan lazim agronomi supaya pengeluaran hasil dapat dikekalkan.

CHAPTER I

INTRODUCTION

The oil palm industry is the largest industry in the agricultural sector in Malaysia, occupying approximately 2.30 million hectares in 1994 or 7% of the country's total land area. This industry contributes 25% of agricultural gross domestic products (GAP) and 5% of national gross domestic products (GNP) (Hock et al., 1995).

Because of its sheer size, the oil palm industry produces large amounts of waste. Megat Johari et al. (1990), Mohamad et al. (1985), Abd. Halim and Kong (1980) and Chan et al. (1980 and 1981) reported that the oil palm industry produces trunk and frond residues in the field and shell, empty fruit bunch, pressed fiber and palm oil mill effluent at the mill. These residues or wastes can be hazardous to the environment if not properly managed.

The approach in managing these wastes has been towards their effective utilization and changing them into value added products, while removing them from potential hazardous impact on the environment. Many efforts have been fruitful. In respect of the oil palm fronds which represent 70% of residues in the field (Mohamad et al., 1985), vitamin E, in particular homologue x-tocophenols, can be

extracted from the leaves and subsequently used in the pharmaceutical and food industry (Abd. Gapor and Kato, 1985). The leaves can also be used as a source of food for ruminants (Abu Hassan and Azizan, 1992) while the petiole can be processed to make paper and soft board (Hishamuddin et al., 1987). These successes have greatly expanded the growth of agro-based industries.

In the traditional agronomic practice, the oil palm pruned fronds are organically recycled by stacking on one another on the frond avenue as mulches and left to decompose naturally. According to Hishamuddin et al. (1987) and Huan (1989), the oil palm fronds pruned from mature palms at the rate of 24 fronds y^{-1} can contribute approximately 10.0 t dry matter or biomass per hectare per year which can be reused. Meanwhile Chan et al. (1981) reported that at an initial density of 148 palms ha^{-1} and at 85% effective stand, 11.7 t ha^{-1} y^{-1} of biomass can be produced. Based on these, the organic matter content of the 0-15 cm soil surface would increase by 0.5% every year if all biomass were returned to the soil.

Mohd Hashim and Yeoh (1985) reported in order to ascertain that soil organic matter is continuously added and sustained in the field, it is important that the pruned fronds are returned to the soil. Their removal will cause a reduction in the organic matter content and nutrient contents. Mohamad et al. (1986) supported the above suggestion based on the result of the study carried out by themselves. According to PORIM annual research reports (1994), the cumulative average (1989-1993) yield of oil palm at FELDA Kertih, Terengganu decreased by 1.43 t ha^{-1} or

8.5% to 16.84 t ha^{-1} when 100% of pruned fronds were shifted to other places compared to the yield from areas where fronds were not shifted. Previously, a study made by Zin Zawawi and Ahmad Tarmizi (1983) found that bigger bunches were produced by palms in the area where fronds were not removed. Thus a stiff competition arises for the oil palm frond usage between its use as a raw material for the agro-based industries and its requirement for recycling in the field. Therefore, it is important to determine the number of pruned fronds that should be retained in the field for improving the soil quality and subsequently the oil palm yield. The balance can be used for agro-based industries.

One of the main challenges for the oil palm industry is to raise productivity in the face of reduced availability of labour. This implies greater need for mechanization. A common practice is to use alternative rows between palms for operations such as harvesting, weeding, fertilization and transporting fresh fruit bunch. Heavier machines are being utilised to offset labour and this has resulted in a gradual deterioration of soil physical properties such as compaction (Mohd Mokhtaruddin et al., 1993). The negative effects of soil compaction on soil properties and on the subsequent crop yield have been well documented (Soane, 1990, Hulugalle et al., 1984, Mbagwu et al., 1984, Lal, 1981 and Corley et al., 1976).

About half of the total area in an oil palm plantation comprises the harvesting path. Therefore, soil compaction is very widespread and the impact on the total soil productivity is expected to be very significant. The soil organic matter content is much lower at the harvesting path compared to the frond avenue especially when the age of oil palm is more than 10 years. At this stage almost all cover crop that helped to maintain soil quality have died because of the shading effect. Soil physical property deterioration is found directly related to the reduction of soil organic matter content (Mbagwu, 1992; Bruce et al., 1992 and Lal and Stewart, 1990). Based on this information, the soil compaction and other soil physical properties at the harvesting path can be ameliorated with the addition of organic matter. In this regard the oil palm wastes especially the fronds can be used as the source of organic matter. Many researchers have tried to develop sustainable soil management alternatives for rehabilitating deteriorated lands in the tropics. Mbagwu et al. (1984) suggested that on most soils in the tropics, for soil-management practices to be effective and reduce the fertilizer requirement, they should aim at ameliorating the deteriorated physical properties. As reported by Warkentin (1995), soil quality is the key to sustainable agriculture.

In order to sustain crop productivity in the future, we have to embark on a new strategy to improve the soil physical properties along the harvesting path without disturbing the mechanization. The differences in soil organic matter content and quality of soil physical properties between the harvesting path and frond avenue have to be minimized. The better soil environment that eventually develops would

be expected to increase the oil palm yield. Therefore the major objective of this thesis is to study the field decomposition of oil palm frond and its effects on the soil physical properties while the specific objectives are to analyze the influence of different rates of oil palm frond placement in the field on its decomposition rate and to study the changes in soil physical properties at the harvesting path due to the frond mulch. The information obtained can be utilized to develop guidelines in the field utilization of harvested fronds in the oil palm plantation.